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(54) **NI-H2 BATTERY HAVING IMPROVED THERMAL PROPERTIES**
NI-H2 BATTERIE MIT VERBESSERTEN TEMPERATUREIGENSCHAFTEN
ACCUMULATEUR NI-H2 AUX PROPRIETES THERMIQUES AMELIOREES

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a common pressure vessel type Ni-H_2 storage battery, which may be used, for example, in powering satellites. More particularly, the invention relates to a common pressure vessel type Ni-H_2 storage battery having improved heat transfer properties between individual battery cells of the cell stack and the walls of the pressure vessel of the battery.

[0002] The earliest Ni-H_2 batteries for satellite application employed individual pressure vessels for each cell in the battery. However, to gain improvements in specific energy and energy density and to reduce the total weight and volume of the battery, the recent trend has been to incorporate multiple cells in a stack arrangement within a single pressure vessel. This type of Ni-H_2 battery is termed in the art a common pressure vessel type battery. Examples of common pressure vessel type Ni-H_2 batteries are described in the following publications: M. Earl et al., "Design and Development of an Aerospace CPV Ni/H_2 Battery", 24th Intersociety Energy Conversion Engineering Conference, Washington, D. C., August 1989, Proc., Vol. 3, pp. 1395-1400; J. Dunlop et al., "Making Space Nickel/Hydrogen Batteries Light and Less Expensive", AIAA/DARPA Meeting on Lightweight Satellite Systems, Monterey, California, August 1987, NTIS No. N88-13530; G. Holleck, "Common Pressure Vessel Nickel-Hydrogen Battery Design", 15th Intersociety Energy Conversion Engineering Conference, Seattle, Washington, August 1980, Proc., Vol. 3, pp. 1908-1911; and E. Adler et al. "Design Considerations Related to Nickel Hydrogen Common Pressure Vessel Battery Modules", 21st Intersociety Energy conversion Engineering Conference, San Diego, California, August 1986, Proc., Vol. 3, pp. 1554-1559.

[0003] In Ni-H_2 batteries, considerable waste heat is generated during both charge and discharge portion of cycles. In the conventional common pressure vessel type Ni-H_2 battery, the individual cells were generally disposed inside of an insulating carrier. The thermal path between the heat generating portions of the cells and the wall of the pressure vessel was lengthwise through the battery cell stack components and then through the hydrogen gas of the battery to the adjacent wall of the pressure vessel. As a result, the thermal resistance between the individual cells and the pressure vessel was high, resulting in undesirable large temperature increases within the battery.

[0004] A metal oxide hydrogen battery having heat transfer properties is known from US-A-5071652.

SUMMARY OF THE INVENTION

[0005] It is therefore an object of the invention to provide a common pressure vessel type Ni-H_2 battery in which the thermal resistance between the individual cells and the pressure vessel of the battery is greatly reduced, thereby effecting rapid heat transfer between the cells and the pressure vessel and thus allowing the specific capacity of the battery to be increased.

[0006] In accordance with the above and other objects, the invention provides a battery including a pressure vessel, and a plurality of compartments disposed in side-by-side relation, each of the plurality of compartments including a heat transfer member having a fin portion and a flange portion extending longitudinally from the fin portion, the flange being in thermal contact with an inner wall of the pressure vessel, and a plurality of battery cells, at least one battery cell being disposed in each of the compartments and in thermal contact with adjacent fin portions of the heat transfer members ; and a cell spacer for maintaining adjacent heat transfer members of adjacent compartments a predetermined distance from one another.

[0007] Preferred embodiments are claimed in the dependent claims 2 to 6.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is partially cut-away cross-sectional view of a common pressure vessel type Ni-H_2 battery constructed in accordance with a preferred embodiment of the present invention;
Fig. 2 illustrates a heat transfer member according to a first embodiment of the invention;
Fig. 3 illustrates the heat transfer member of Fig. 2 making contact with the pressure vessel of Fig. 1;
Fig. 4 illustrates a stack of compartments with an internal cell spacer;
Fig. 5 illustrates a stack of compartments with an outer end cell spacer;
Fig. 6 illustrates two battery cells disposed within a heat transfer member of Fig. 2;
Fig. 7 shows an enlarged fragmentary longitudinal section of the battery of Fig. 1 showing a group of compartments including a heat transfer member, battery cell, cell spacer, and end cell spacer;
Fig. 8 is an enlarged cross-sectional view showing the relationship between the vessel wall, heat transfer member, individual battery cells, cell spacer, and spacer;
Fig. 9 illustrates a cross-sectional view illustrating the mode of interconnecting adjacent battery cells;
Fig. 10 illustrates a heat transfer member according to a second embodiment of the present invention; and
Fig. 11 illustrates a heat transfer member according to a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] Preferred embodiments of the invention will now be described with reference to the attached drawings.

[0010] Referring to Fig. 1, a pressure vessel 5 of a preferred embodiment of a Ni-H_2 battery 1 of the invention is composed of a central cylindrical portion 4 capped at respective ends by end portions 2 and 3. Within the pressure vessel 5, there is a stack 6 of individual cylindrical compartments 20 disposed in side-by-side relation. The outer wall of the stack 6 of the cylindrical compartments 6 conforms to the shape of the central cylindrical portion 4 such that the outer wall of the stack is in thermal contact throughout its surface with the inner wall or surface of the central cylindrical portion 4 of the pressure vessel 5. As will be described below in more detail, each compartment 20 is composed of at least one battery cell 80, a heat transfer member 21, and a cell spacer 22 or an end plate 24 as shown in Fig. 5, for example.

[0011] Figs. 2 and 3 illustrate the heat transfer member 21, which serves to transfer heat radially outward from the center of the battery to the inner wall of the pressure vessel 5 and thence into the surrounding atmosphere. The heat transfer member 21 is made of an aluminum or any other material having a high coefficient of thermal conductivity. According to a first embodiment of the invention, the heat transfer member 21 includes a circular-shaped fin or body 21a having a cut-out 21d and a plurality of integral flanges 21b, which are separated from one another by a plurality of slits 21c. The flanges 21b extend longitudinally from the body 21a so as to form an "L-shape" fron a cross-sectional view of the heat transfer member 21. The flange 21b also forms the outside wall of the compartments 20, which is in thermal contact with the inner wall of the vessel 5.

[0012] As illustrated in Fig. 3, the flange 21b forms an obtuse angle θ with the fin or body 21a of the heat transfer member 21 so as to insure a firm thermal contact between the flange and the inner wall of the vessel when inserted into the pressure vessel 5. When the heat transfer members 21 are inserted into the vessel, the flanges 21b are deflected or bent inward and due to the flexibility of the flanges a radial force or biasing action will be exerted so as to maintain the segments in tight engagement with the inner wall of the vessel. This further ensures that as heat is extracted from within the vessel, the heat is sufficiently transferred to the vessel and subsequently to the surrounding atmosphere.

[0013] Referring to Figs. 8 and 9 and as described in commonly assigned patent application serial no. 07/711,602, which is herein incorporated by reference, each battery cell 80 is of generally semi-cylindrical or cylindrical shape and contains a repeating pattern of a gas diffusion screen 82, negative electrode 83, separator 84, and positive electrode 85. The arrangement and selection of the materials for these components is conventional and well within the skill of those familiar with this art. Each cell 80 is encased, for example, by a plastic bag 81, which electrically insulates the above-mentioned components from the fins 21 and spacers 22. The outer sides of the bag 81, however, are in intimate thermal contact with the fins 21a of the heat transfer member 21 on both sides of the cell so as to provide good thermal conduction between the cell 80, over its entire surface, and the heat transfer member 21.

[0014] Fig. 6 illustrates the manner in which two generally semi-cylindrical battery cells 80 are situated within a heat transfer member 21, while Figs. 7 and 8 illustrate the encasing 81 of a battery cells 80 being in intimate thermal contact with adjacent fins 21a of adjacent heat transfer members 21. Figs. 7 and 8 also illustrate that the length of the flange 21b can vary relative to the width of a battery cell 80 and compartment 20. That is, the maximum length of a flange 21b will allow the end of the flange to come in contact with the adjacent heat transfer member 21. Preferably though, the length of the flange is less than the width of a compartment 20 or battery cell 80 so that the distance between adjacent heat transfer members 21 is determined by the spacers 22 as described in more detail below. However, the length of the flange must be of a certain length to provide a sufficient amount of surface contact between the flange and the inner wall of the vessel 5 so that a sufficient amount of heat can be withdrawn.

[0015] Again referring to Figs. 7 and 8, the heat transfer member 21 of a first compartment is spaced from the heat transfer member 21 of an adjacent compartment by the cell spacer 22, which is generally of a ring-shape, as illustrated best in Fig. 4. First and second sides of the spacer come into contact with the fin or body 21a of adjacent heat transfer members 21. The cell spacers 22 are made of a rigid material (e.g., aluminum) such that the heat transfer members 21 are held stationary and at a relatively constant distance from one another. The spacers 22 also provide for the compartments 20 to remain at a relatively constant compression. As shown in Figs. 5 and 8, the outer compartment 20 is spaced by an end cell spacer 24, which is composed of a ring-shaped portion 24a, similar to a cell spacer 22, and an integral circular body portion 24b with a cut-out 24c.

[0016] Referring now to Fig. 9, each cell 80 has positive electrode terminals 86 and negative electrode terminals 87 which are respectively connected to the positive and negative electrodes 85 and 83 of the cell 80. The battery cells 80 of a compartment 20 can be connected to the battery cells of an adjacent compartment in series or in parallel to obtain the desired voltage output. The connection of adjacent terminals can be through the use of insulated interconnecting rods 36 and 46 which pass through center holes of the terminals 86 and 87, respectively, and through the cut-outs 21d of each of the heat transfer members and the cut-out 24c of the end cell spacer 24. The connection between battery cells and from the battery cells to external positive

and negative electrodes 9, 10 can be similar to that which is described in the aforementioned patent application.

[0017] Referring back to Fig. 1, first and second weld rings 7 secure the outer end portions 2 and 3, to the center cylindrical portion 4 and also hold the stack of compartments in place so as to prevent any shifting of the stack 6 of the compartments 20 in the axial direction. A wave spring 8 is disposed between the end cell spacer 24 of the stack and the weld ring 7. The wave spring 8 provides a preloading force on the stack of compartments in the axial direction thereof as well as absorbing any vibration or shock.

[0018] Figs. 4 and 5 illustrate a exploded views of a stack 6. Specifically, Fig. 4 illustrates two battery cells 80 placed within a heat transfer member 21. A cell spacer 22 abuts the fin portion 21a of the heat transfer member and around the outer periphery of the two battery cells 80. Fig. 5 illustrates the outer end compartment in which the ring-shaped portion 24b of the end cell spacer 24 is placed against the fin 21a of the heat transfer member 21 and around the outer periphery of the two battery cells 80. The circular body 24a of the end cell spacer 24 rests in contact with the bag 81 of the cell 80. The cutout 24c allows the rods 36, 46 to pass therethrough.

[0019] With the above-discussed battery structure, heat generated within each battery cell 80 is rapidly transferred through the heat transfer members 21 from the fin body 21a to the flanges 21b, and thence, due to the tight contact between the inner wall of the pressure vessel and the flange, to the pressure vessel 5. As a result, the thermal conductivity between the battery cells 80 and the pressure vessel 5 is greatly improved compared with a conventional common pressure vessel type $Ni\text{-}H_2$ battery.

[0020] Several alternatives and variations of the above-described battery are possible. For example, as shown in Fig. 10, the heat transfer members 21 can be semi-circular in shape as well as the spacers. In this case, two stacks of compartments, each compartment being generally semi-cylindrical in shape, are assembled together to form a cylindrical shape. That is, each of the stack of compartments has an outer wall having the shape of a cylinder sliced lengthwise along a plane slightly offset from the longitudinal axis of the cylinder so that a small gap is provided between the two cell stacks. The two stacks of compartments once assembled are inserted into the vessel 5. Provisions for maintaining the gap between the two stacks are well known in the art, and a suitable example is illustrated and described in the aforementioned patent application.

[0021] Other embodiments include a heat transfer member of a "T-shape" such as that shown in Fig. 11. Here, the heat transfer member includes a fin body 21a and a plurality of flanges 21b, 21b' extending longitudinally from both sides of the fin 21a. The flanges 21b, 21b' are separated by a plurality of slits 21c, 21c'.

[0022] There has thus been shown and described a novel $Ni\text{-}H_2$ battery having improved thermal properties which fulfills all the objects and advantages sought therefor. Many changes, modifications, variations and other uses and applications of the subject invention will, however, become apparent to those skilled in the art after considering the specification and the accompanying drawings which disclose preferred embodiments thereof. All such changes, modifications, variations and other uses and applications which do not depart from the scope of the invention are deemed to be covered by the invention which is limited only by the claims which follow.

Claims

1. A battery comprising:

   a pressure vessel (5); and
   a plurality of compartments (20) disposed in side-by-side relation, each of said compartments comprising:
   a heat transfer member (21) having a fin portion (21a) and a flange portion (21b) extending longitudinally from said fin portion, said flange being in thermal contact with an inner wall of said pressure vessel (5);
   a plurality of battery cells, at least one battery cell being disposed in each of said compartments (20) and in thermal contact with adjacent fin portions (21a) of said heat transfer members; and
   a cell spacer (22) for maintaining adjacent heat transfer members (21) of adjacent compartments a predetermined distance from one another.

2. A battery as defined in Claim 1, wherein said cell space is ring-shaped.

3. A battery as defined in claim 1, further comprising first and second weld rings (7) and a wave spring (8), and wherein a first outer one of said compartments comprises an end cell spacer (24), said first weld ring being in contact with a heat transfer member of a second outer compartment, and said wave spring being in contact with said end cell spacer and said first weld ring so as to provide a preloading force on said stack of compartments.

4. A battery as defined in claim 1, wherein the length of said flange portion of said heat transfer member is less than the width of said battery cell.

5. A battery as defined in Claim 1, wherein the length of said flange portion of said heat transfer member is the same as the width of said battery cell.

6. A battery as defined in Claim 1, wherein said flange

portion (21b) forms an obtuse angle with said fin portions (21a).

Patentansprüche

1. Batterie, mit

   - einem Druckgefäß (5) und
   - einer Vielzahl von Fächern (20), die Seite an Seite angeordnet sind, wobei jedes Fach folgende Bestandteile umfaßt:

     - ein Wärmeübertragungselement (21), das einen Flossenteil (21a) und einen Flanschteil (21b) aufweist, der sich in Längsrichtung ausgehend vom Flossenteil erstreckt, wobei der Flanschteil in thermischem Kontakt mit einer Innenwand des Druckgefäßes (5) steht,
     - eine Vielzahl von Batteriezellen, wobei wenigstens eine Batteriezelle in jedem der Fächer (20) und in thermischem Kontakt mit benachbarten Flossenteilen (21a) der Wärmeübertragungselemente angeordnet ist, und
     - einen Zellenabstandshalter (22) der dazu dient, benachbarte Wärmeübertragungselemente (21) von benachbarten Fächern voneinander in einem vorbestimmten Abstand zu halten.

2. Batterie nach Anspruch 1, bei der der Zellenraum ringförmig ist.

3. Batterie nach Anspruch 1, die weiterhin erste und zweite Schweißringe (7) und eine Wellenfeder (8) umfaßt und bei der ein erstes äußeres Fach einen Endzellen-Abstandshalter (24) umfaßt, wobei sich der erste Schweißring mit einem Wärmeübertragungselement eines zweiten äußeren Faches in Berührung befindet und sich die Wellenfeder mit im Endzellen-Abstandshalter und dem ersten Schweißring in Kontakt steht, um eine Vorspannungskraft auf den Stapel von Fächern auszuüben.

4. Batterie nach Anspruch 1, bei der die Länge des Flanschteils des Wärmeübertragungselementes kleiner ist als die Breite der Batteriezelle.

5. Batterie nach Anspruch 1, bei der die Länge des Flanschteils des Wärmeübertragungselementes die gleiche ist wie die Breite der Battenezelle.

6. Batterie nach Anspruch 1, bei der der Flanschteil (21b) einen stumpfen Winkel mit dem Flossenteil (21a) bildet.

Revendications

1. Accumulateur comprenant:

   - Un récipient sous pression (5);
   - Une pluralité de compartiments (20) disposés côte à côte, chacun desdits compartiments comprenant:
   - Un élément de transfert de chaleur (21) ayant une partie d'ailette (21a) et une partie de bride (21b) s'étendant longitudinalement à partir de ladite partie d'ailette, ladite bride étant en contact thermique avec une paroi interne du récipient sous pression (5);
   - Une pluralité de cellules d'accumulateur, au moins une cellule d'accumulateur étant disposée dans chacun desdits compartiments (20) et en contact thermique avec des parties d'ailette adjacentes (21a) desdits éléments de transfert de chaleur ;
   - Un espaceur de cellules (22) pour maintenir les éléments de transfert de chaleur adjacents de compartiments adjacents à une distance prédéterminée les uns des autres.

2. Accumulateur selon la revendication 1, dans lequel ledit espaceur de cellules est de forme annulaire.

3. Accumulateur selon la revendication 1, comprenant en outre des premier et second anneaux soudés (7) et un ressort à ondulation (8), et dans lequel un premier compartiment externe parmi lesdits compartiments comprend un espaceur de cellules d'extrémité (24), ledit premier anneau soudé étant en contact avec un élément de transfert de chaleur d'un second compartiment externe, et ledit ressort à ondulation étant en contact avec ledit espaceur de cellules d'extrémité et avec ledit premier anneau soudé de manière à fournir une force de précompression sur ladite pile de compartiments.

4. Accumulateur selon la revendication 1, dans lequel la longueur de ladite partie de bride dudit élément de transfert de chaleur est inférieur à la largeur de ladite cellule d'accumulateur.

5. Accumulateur selon la revendication 1, dans lequel la longueur de ladite partie de bride dudit élément de transfert de chaleur est identique à la largeur de ladite cellule d'accumulateur.

6. Accumulateur selon la revendication 1, dans lequel ladite partie de bride (21b) forme un angle obtus avec ladite partie d'ailette (21a).

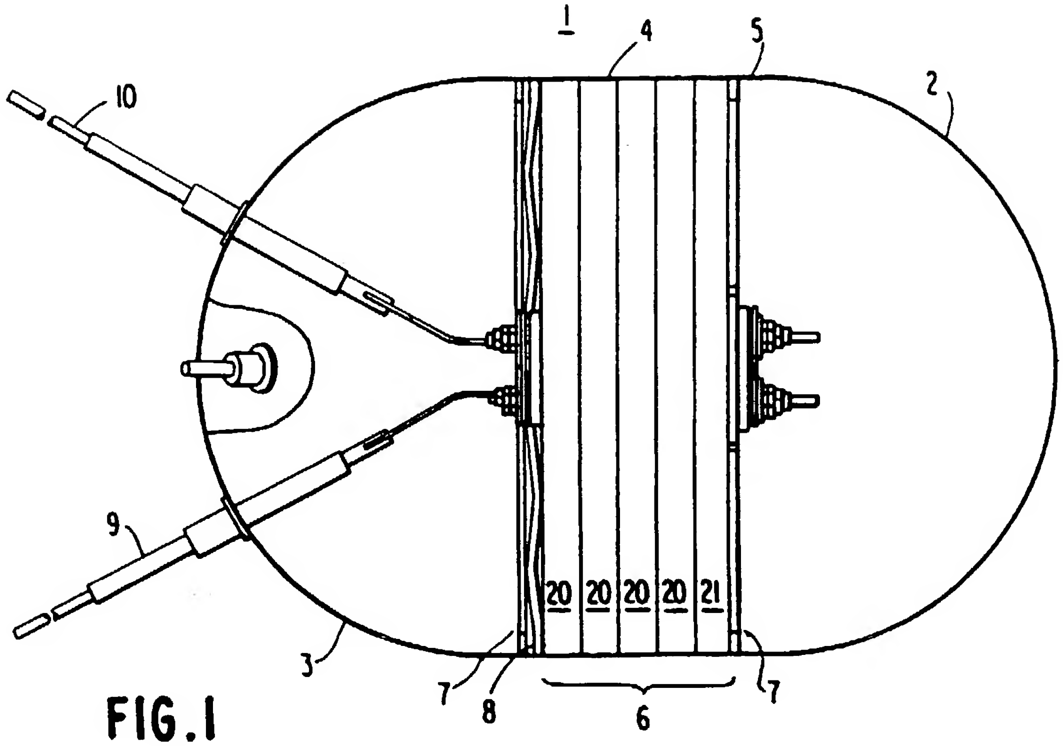
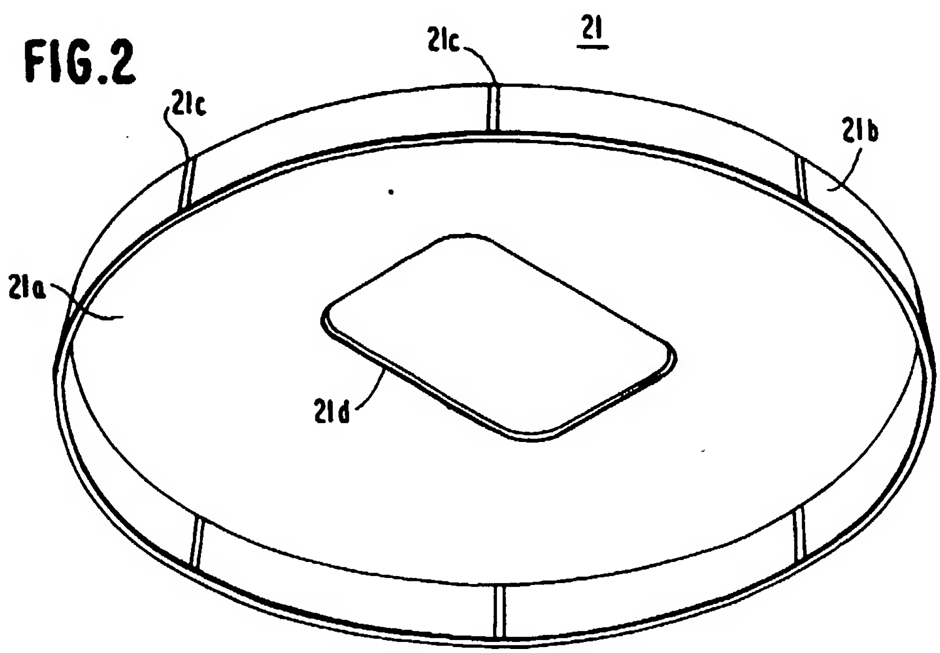


FIG.1

FIG.2



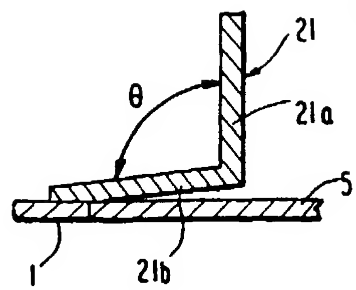


FIG. 3

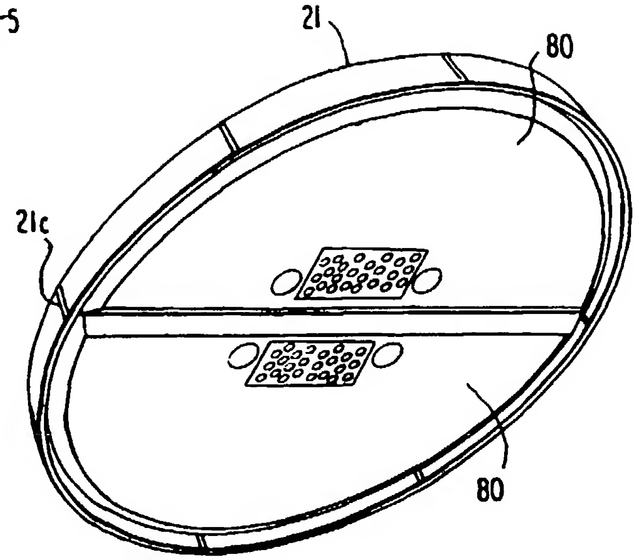


FIG. 6

FIG. 4

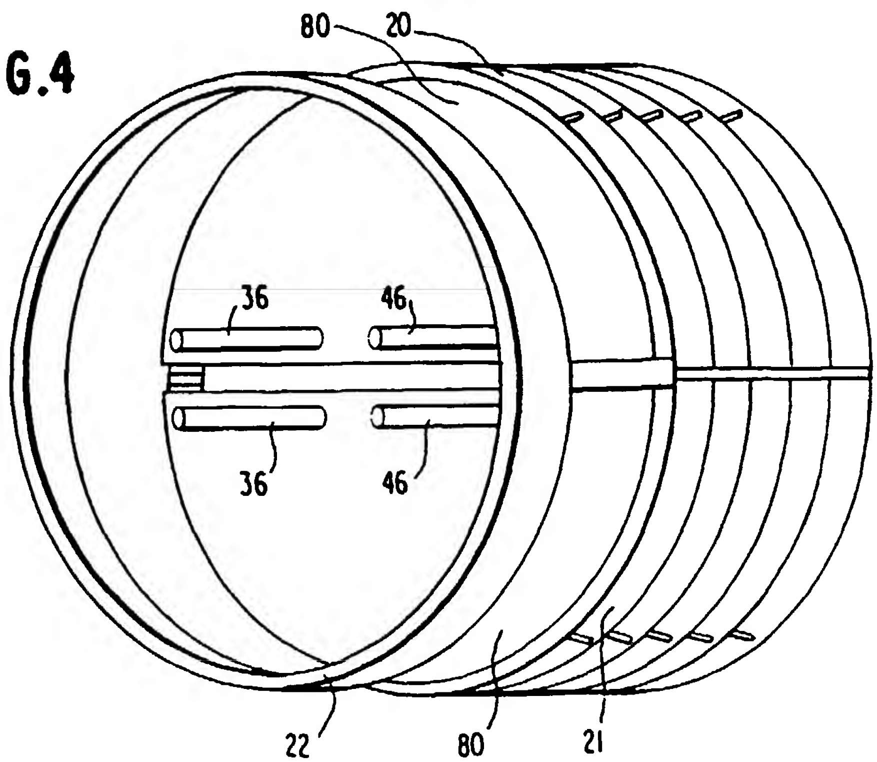


FIG.5

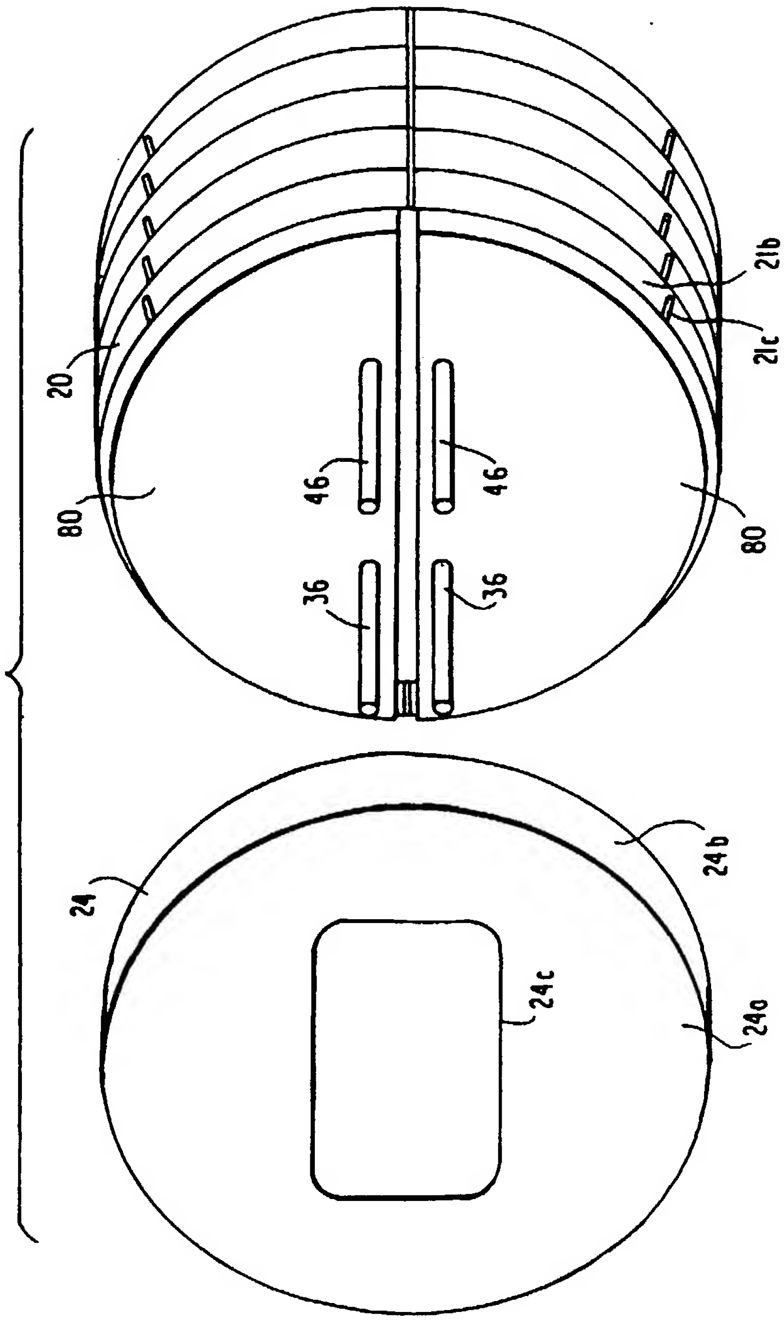
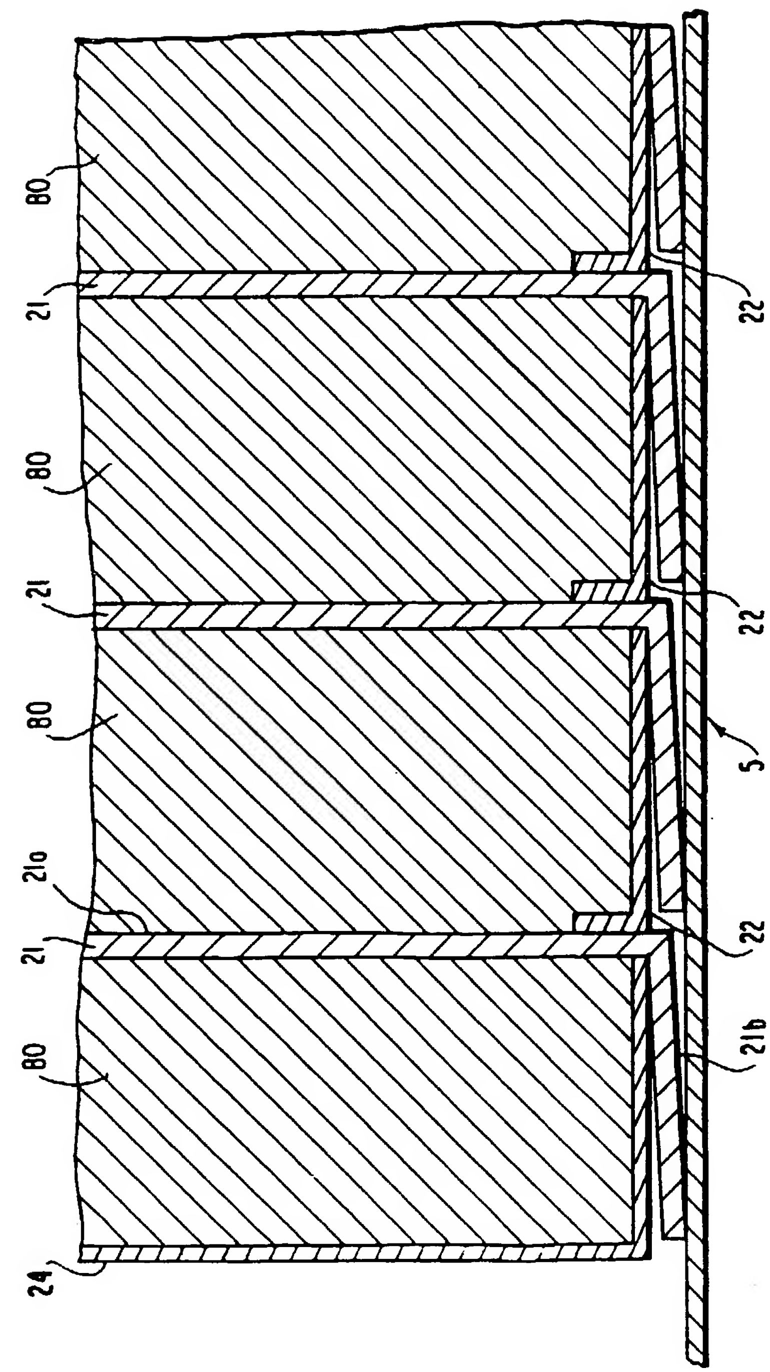


FIG. 7



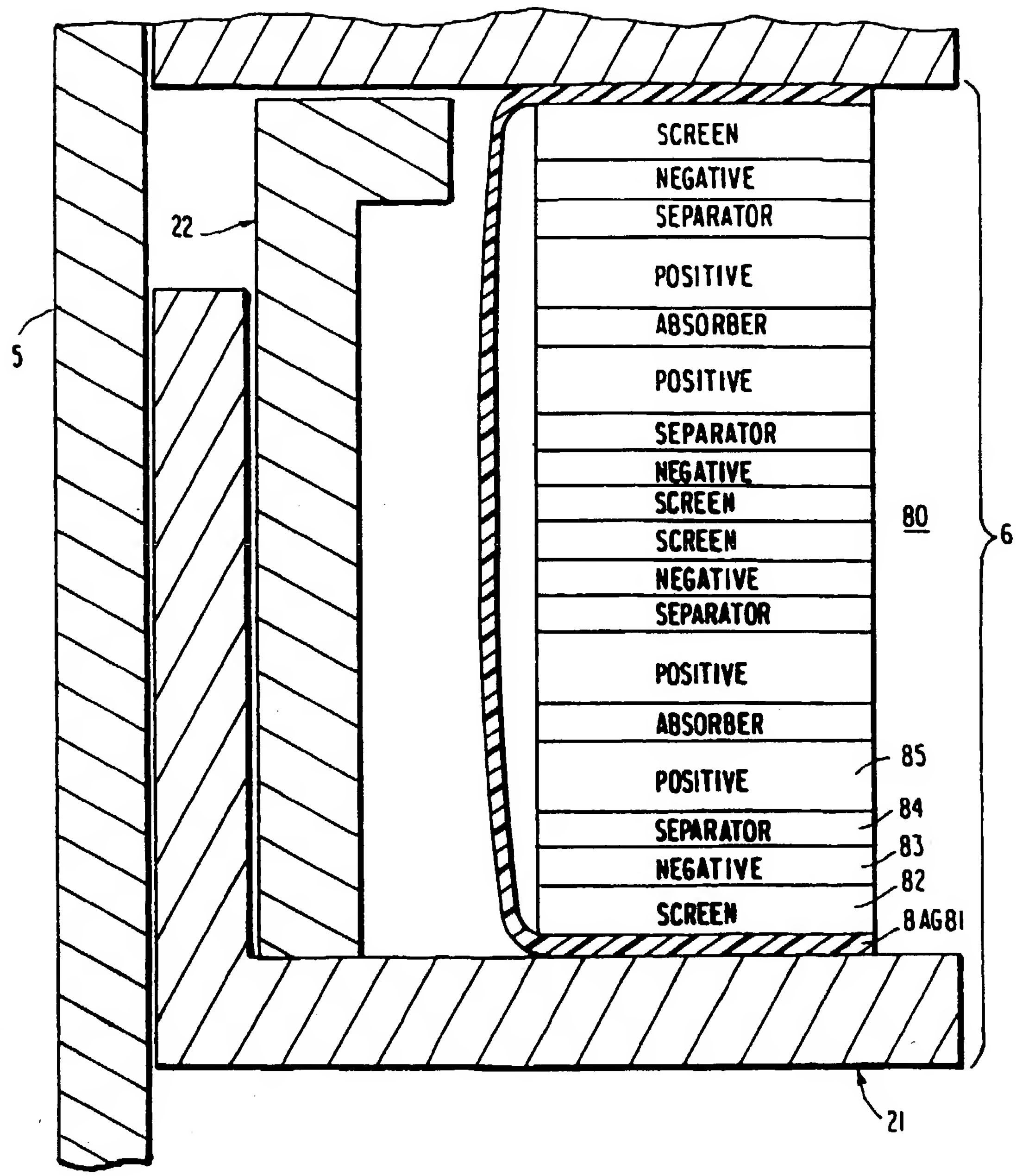

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FIG.8

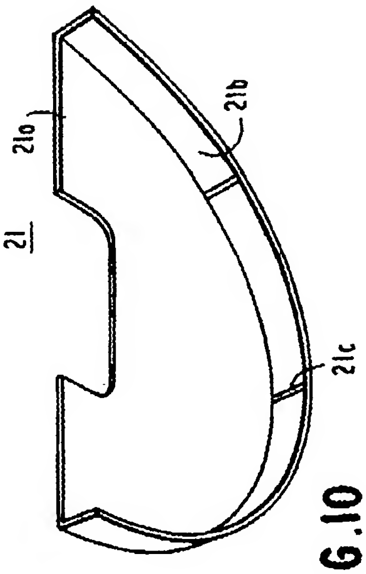

FIG.10

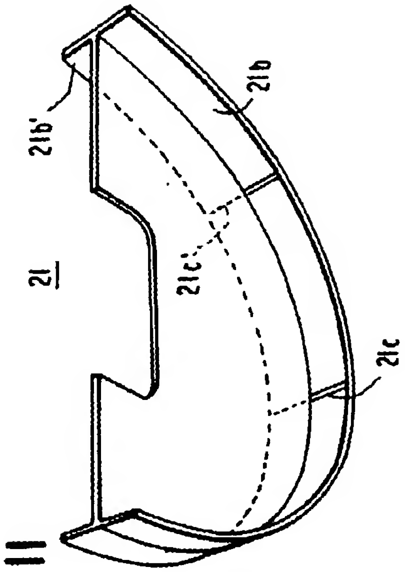

FIG.11

FIG.9